International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 08 | Aug 2020 www.irjet.net p-ISSN: 2395-0072

Design and Development of Pick and Place Arm Robot

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Abstract – *This work involves designing and fabricating a simple pick and place arm type robot that could be used in handling of parts during different production process. The production process may include machining, sheet metal operation, and assembly of simple parts etc. The problem is made very specific with the design objective of picking objects like plastic caps, glass blanks as used in horological industries, small sheet metal parts, etc., from one work station to another work station. The part is considered to be with weight about 100 grams. This research work helps in integrating various disciplines such as Mechanical, Pneumatic and Electrical. A systematic design process has been adopted from literature review to the manufacturing. During design conceptualization latest CAD soft tools was involved in developing the 3D model, assembly and 2D drawing. The robot arm is designed with simple design where the transformation of the components is carried out using the pneumatic cylinders and the suction grippers. Entire electro pneumatic circuit has been developed by using Festo-Fluidsim software. The implementation of the robot was successfully completed and studied for initial cost, Time required for part transfer, and number of pieces transferred. The initial cost for the system was little higher when compared to the manual system since the robot involves electro pneumatics, however, the parts transferred is higher by two folds and time taken for the part transfer is less. Result shows that the time taken for the transfer of part from one station to another has largely reduced and number of pieces transferred has largely increased.*

Key Words: *PPAR* - Pick and Place Arm Robot, *SCARA*-Selective Compliant Assembly Robot Arm, Electro Pneumatics, Vacuum gripper.

Nomenclature	
d	Distance between the centre axis of the support and axis of cylinder, m
E	Modulus of Elasticity, GPa
g	acceleration due to gravity, m/s^2
I	Second moment of Area, m^4
L	Length of the arm on one side, m
m_c	Mass of the cylinder, kg
m_s	Mass of the suction cup and its assembly, kg
m_o	Mass of the object, kg
m_a	Mass of one side of the arm, kg

1. INTRODUCTION

According to International Standards Organization (ISO) the robot is defined as, "Industrial robot is an automatic, servo controlled, freely programmable, multipurpose manipulator, with several areas for the handling of work pieces, tools or special devices". A Pick and Place Arm Robot (PPAR) is one of the big machines which performs a specific activity in the current modern manufacturing industries. It serves the purpose of effective time management as the packaging industries involve the arrangement and transformation of various raw materials to attain the final output. The cost of material handling activities range from 50-75% of the total time taken for handling the materials manually. Thus, it saves time and energy simultaneously.

Moreover, Automation avoids a lot of monotonous manual labour and speeds up the creation processes. The project has the scope for picking and placing the objects from one station to the other, by using a simple manual operated electro-pneumatics. This project could be implemented in industry to minimise the workforce and laboratories in the educational institutions where the work piece like simple glass, wood, sheet metal weighing about 50-100 grams can be picked and placed. This kind of machine further used in the assembly lines for transferring bolt and nut with a little modification in the gripper. Modern robotic systems consist of two different significant parts. First, the manipulator and second is the device that actuates the joints of the manipulator.

The construction of a manipulator is composed of the main structure and a wrist alongside a foot attached to its end. The instrument got manufactured by welding the head and comprises of a squirt gun, a machining instrument, or a vacuum gripper, reliant on the specific requests of the robots. Every side of arm encompasses a sequence or mechanical links that relates the vacuum gripper to the attached part. The purpose of the vacuum suction is to select and locate the position of the materials amid the two stations. By adding electronics, electro-pneumatic actuators, controllers and other required mechanisms, the human capabilities augment to improve manufacturing. In many cases, there are valid reasons for assisting humans.

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1.1 Literature review

Since many years' replacement of human work with mechanization and automation are in practice. It is observed and been proved that the robots are faster and more effective than human work. Robot is an electro-mechanical device or contrivance that can be used for self-governing tasks. Currently many robots are utilized for tasks that are so tough or hazardous for the humans for apply undeviatingly such as picking and allocating the objects withal, it can be utilized to automate the perpetual tasks that can give alongside extra precision. Rajgure S.D et al [2018] has reviewed the modeling of pneumatic robotic arm for automation in two machines, for material handling purpose. The review was between the two machines namely extrusion and belt grinding machine. It was commanded to design the pneumatic arm to pick and place the cylindrical object like steel bars. It has presented forward and inverse kinematics of robot arm and reveals that a robotic arm can be manufactured by using cellular titanium and nano crystalline aluminum in order to ensure less weight. In some of the work PLC program are used to control the arm robot, but it needs more costs, skill and knowledge to make it and connecting to the arm robot.

Harish K et al [2017] tried extracting the signals with the help of Arduino and to send to receiver flag to check for any applied instructions provided to the controller. With the instruction decoded and stored back to the DATA variable, algorithm checks for opcode with the code stored in DATA variable. Accordingly, the robot locate itself as well as the object to be lifted with the usage of dc motors and chassis. Kaustubh Ghadge et al [2018] used Node MCU from Microchip Technology to control system and all other activities performed by the Robot Arm for Pick and Place applications. Android application will be sent to Node MCU to respond consequently. CAD modelling of various parts of the robot are performed. Pneumatic system components are more familiar to use in arm robot.

Vishakha Borkar and Andurkar G.K [2017], has developed pick and place Robot for industrial applications. The design is carried out on a low-cost robot platform for development of pick and place the things. There is establishment of both wireless communication between the mobile robot and the remote base station, and serial communication between the remote base station and the GUI application. The base station requires the serial communication with the GUI application and also needs to be hardwired with the radio packet controller. The work has aimed in command and control the Robot wirelessly by the GUI application and successfully done the wireless communication and the serial communication in the demodulation scheme.

Vacuum gripper is more familiar to make the hand of robot arm which is used for picking and placing the objects, and not expensive.

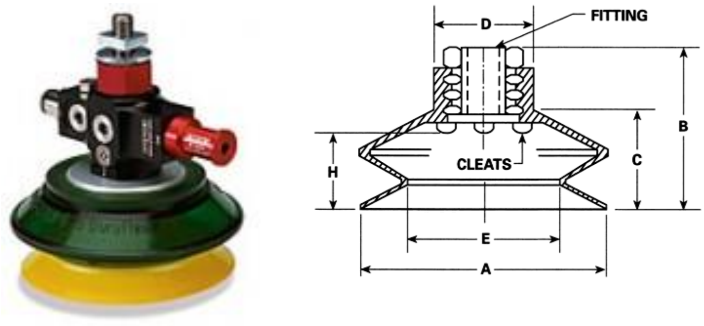


Figure 1 Vacuum Gripper Assembly and its sectional shape

Bicci A and Kumar V [2000], indicates Vacuum grippers are used in the robots for grasping the materials and objects in packets. It uses vacuum cups as the gripping device as shown in Figure1, which is also commonly known as suction cups. This type of grippers will provide good handling if the objects are smooth, flat, and clean and stored in cartoons. It has only one surface for gripping the objects. It may not be suitable for handling the pores objects all around. Kragten G A and John R. Amend [2011] have elaborated vacuum gripper under actuated hands that involve fundamentals performance analysis and design. Eizicovits et al. [2014] have presented efficient sensory grounded grasp pose quality mapping for vacuum gripper.

Table 1 gives a schematic comparison between manual, robotic automation and low-cost automation in regard of number of pieces produced per minute, cost involved, and the time taken. Low cost automation shows better solution for industry production process.

Table - 1 Comparison of manual and automatic Robot

Parameters	Manual	Full Automation	Automation (Low cost)
No. of pieces/min	10	20	20
Initial cost	Less	More	Medium
Time	More	Less	Less

2. METHODOLOGY

Methodology is devised through the problem definition and the functional requirement. *The problem considered is to pick a flat surfaced object like sheet metal, glass etc., from one station and place it at the other station.*

2.1 Stage 1: Conceptualization: This is done through manual sketching and later converting them to part and assembly models with 2D drawings using any of the commercially available CAD software's.

a. Initially, the system layout is hand sketched, which takes into account providing a base structure for the robot, this would fix the entire robot system to the table.

b. Over which, two stations are to be built, which is termed to be station 1 and station 2.
c. A central vertical rod or lead screw and nut arrangement which holds a Pinion at the bottom end for rotary movement.
d. This which would be, driven by a rack actuated through a horizontally placed pneumatic cylinder.
e. The top end of the rod is connected to an arm, where there are two cylinder with vacuum grip placed at the end of the piston.

2.2 Stage 2: Function of the PPAR

After the modeling of all parts, they are assembled with proper constraints and relations. The assembly is checked for the working of the designed rack and pinion mechanism through simulation. At the end, the part list is finalized. The following are the major parts used in this system and are modelled. Base frame, rack, pinion, flange, bearing, lead screw and nuts, arm, pneumatic cylinders, vacuum cups, etc. The rotation is fully defined and precise rotation in the arms could be attained with the help of pneumatic system and the micro switches. For incorporating the pneumatic system for rotating the lead screw, moving the gripers to pick and place the object at correct places, the cylinder should have enough capacity, stroke length.

The type (single or double acting) and its control elements (DCV, Solenoids etc.,) should be appropriately selected. The conduits tubes should have more than minimum diameter for avoiding blockages or pressure surge. Filters, Regulator and Lubricators (FRL) unit is connected to the system. Productivity is directly related to the operating method followed, which could be classified as manual, mechanized and electro-pneumatic. The cost and time taken would be large in the case of manual operation, which could be reduced by semi automation. Usage of appropriate mechanical elements have proven the improvement in the productivity. Further introducing electro-pneumatic with control systems will lead to low cost automation.

One complete cycle involves pick of the object at station 1 and rotated through 180° in clockwise direction and place the object at station 2. Further, after placing, the rotation of arm is brought back 180° in the counterclockwise direction. Three double acting pneumatic cylinders are involved for pick, place and rotation. The Festo Fluidsim software was utilized in simulating the developed pneumatic logic circuit. The layout of the electrical circuit was done and incorporated into the control panel to regulate the movement of the pneumatic parts. For the standard parts like cylinders, flow control valves, filter regulator and lubricator, selection was done through the catalogues.

2.3 Stage 3: Design of Arm

Figure 2 represents the schematic arrangements of the cylinder fixed to the arm and supported at the center. The total load acting at the end of the arm W on one side is:

$$W = g * [m_c + m_s + m_o]$$
$$m_c = 1.075\ kg$$
$$m_s = 0.225\ kg$$
$$m_o = 0.1\ kg$$

The arm is designed such that the flexural stiffness is enough to take up the load of the object. The cross-section and its variation along the length are designed limiting the permissible value of deflection at the free end. In this arrangement, uniform hollow rectangular cross-section is selected. From the material properties of the arm, the weight of the arm over the length L on one side from the center axis is W_a. Fixing the material of the arm, E becomes constant. With the constraint of maximum permissible deflection at the end of the arm as less than μm, the minimum required second moment of area I should satisfy

$$I \geq \frac{8Wd^3 + 3W_aL^3}{24000 * E}$$

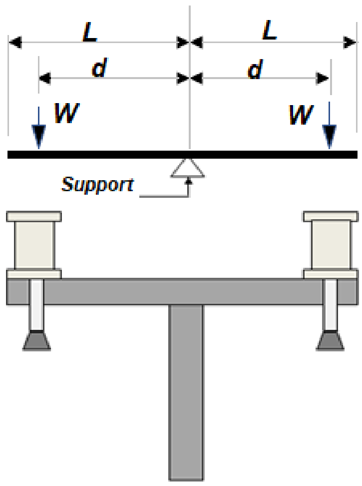


Figure.2 Load on beam

2.4 Stage 4: Fabrication of PPAR

After completing of fabrication and assembly for achieving functionality the PPAR was checked for its accuracy and repeatability. Since the robot has two modes, manual and auto mode for transferring of parts, this model proves worthy in scaling up for handling heavy objects. This will also reduce human fatigue and error in terms of transferring objects from a place to other. From the observation made, the complete experimental setup took about 8 seconds for the transferring the objects from one place to another. The work could be altered with a different stroke length of cylinders with varying weights up to 100 *grams*. Figure 3 represents the flow chart of methodology which is executed in the present work. It begins with the object and ends with assembly and testing.

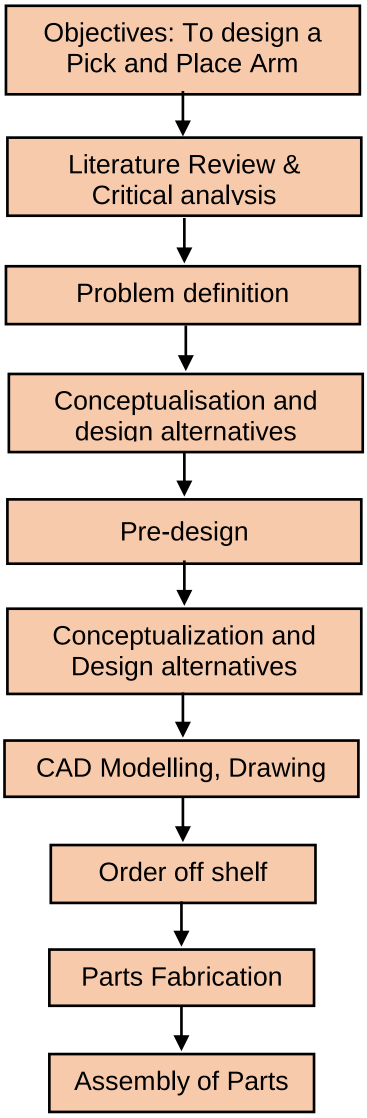


Figure.3 Flow diagram of the Methodology

3.2 ELECTRICAL CIRCUIT DIAGRAM FOR THE PROPOSED DESIGN

Figure 4 represents the circuit diagram for PPAR, the parts involved are briefly indicated.

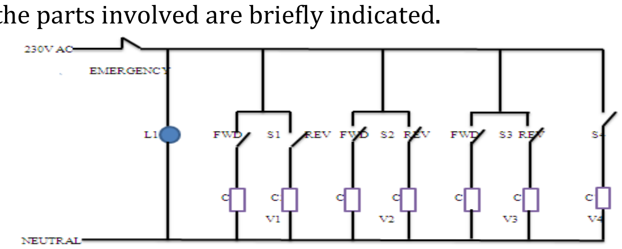


Figure.4 Electrical circuit diagram

Table 2, indicate a list of symbols that explains the cycle movement of the PPAR.

Table - 2 Symbols used and their details

Symbols	Details
S1	FWD/REV switch for suction cylinder left
S2	FWD/REV switch for suction cylinder right
S3	FWD/REV switch for rack pinion
S4	Vacuum ON/OFF switch
V1	Valve for left cylinder
V2	Valve for right cylinder
V3	Valve for rack cylinder
V4	Valve for vacuum ON/OFF
C1 & C2	Solenoid coil for V1
C3 & C4	Solenoid coil for V2
C7	Solenoid coil for V4
C5 & C6	Solenoid coil for V3
L1	Main indicator lamp

3.3 ELECTRO PNEUMATIC CIRCUIT DIAGRAM FOR THE PROPOSED DESIGN

Figure 5 is a schematic representation of the typical Pneumatic circuit which developed by using Festo-Fluidsim software. With three cylinders, each of the cylinders works individually. Table 3 describe the working principle. It indicates the operations at each station of the PPAR. Every cycle involves one pick of the object at station 1 through the Cylinder 1 and vacuum cup and rotate the arm through 180° in clockwise direction and place the object at station 2 by retraction of Cylinder 2. Further, after placing, the rotation of arm is brought back 180° in the counter clockwise direction for continuing with next cycle. For this cycle operation, two modes (manual or Automatic) provisions are available.

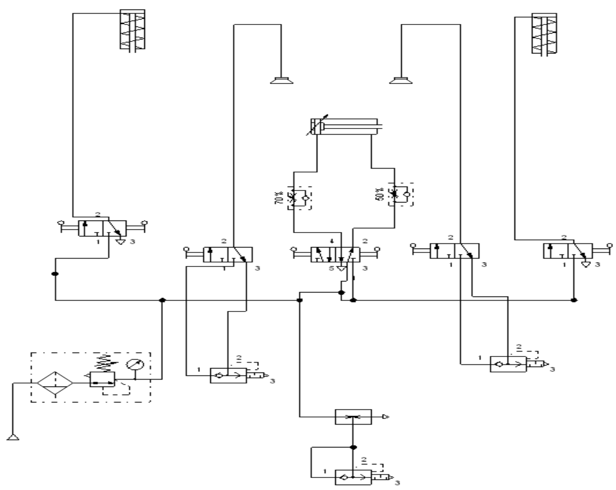


Figure.5 Electro pneumatic circuit diagram

Table 3 Station and Operation

Station	Operation
Station 1	Cylinder 1 piston forward by actuation of DCV, then vacuum suction 1 will grip the material. Cylinder 1 piston retracts with the material. Cylinder 3 piston will forward and actuate the rack and pinion for 180 degree and moves to station 2.
Station 2	Cylinder 1 piston forward by actuation of DCV, then vacuum suction 1 will place the material. Cylinder 1 piston not retracts with the material. Cylinder 2 piston forward by actuation of DCV, then vacuum suction 2 will grip the material in station 1. Cylinder 3 piston will forward and actuate the rack and pinion for 180 degree and moves to station 1.

4.0 RESULTS AND ANALYSIS

On connecting to 230V, the indicator lamp illuminates. The Pneumatic supply is connected to the FRL indicating 6 bar line pressure. The object is placed on Station 1 (Left), Vacuum is switched on. The C2 is switched ON to forward position cylinder to pick the object. The C2 switch is changed over for retract with object lifted by the suction cup. The C3 switch ON the rack moves in forward direction with 180 deg. The rotating arm is now on the other side of the platform. The Vacuum is switched off the object is placed in Station 2. Table 4 indicates the test results of PPAR which was conducted from the fabricated arrangement.

Table 4 Testing results of PPAR

S.NO	Details	Time in (*sec*)
1	Shaft rotation from ***Station1*** to ***Station2***	2.7
2	C1 and C2 (forward and reverse process)	3
3	Pick the object at Station 1	1
4	Place the object Station 2	1

Figures 6 and 7 represents the assembly and control panel of PPAR. The details of testing are indicated below. Total time required for complete the manual process is **(2.7+3+1+1=7.7 = *8 sec*)**

Number of pieces in one minute **: 60/8=7.5**

During one minutes this device can picked and placed ***(7.5 * 2 = 15) pieces***

Number of pieces in one hour **: 15 x 60 = 900**

During one hour this device can picked and placed 900 pieces.

Figure.6 Pick and Place Arm Robot

Figure.7 Control Panel for PPAR

5.0 CONCLUSION

Present work has designed a pick and place arm robot for transfer of parts from a station to another and this was achieved with the help of Electro pneumatics. The work has been successfully completed and all the objectives are met. A provision on manual operation is also provided, which is normally opted during the setting or testing at the preliminary stage. The results are highlighted as below:

- Use of electronic components and pneumatics arrangements instead of servo controlled robot has made the system simple and low cost.
- Reduction of dexterity of human hands. Reduction in the man power required for the pick and place process, since the process is made manually operation.
- Automation of the pick and place process reduces the cycle time which increases productivity thereby reduction in the material handling cost.
- Implementations of pneumatic components, mechanisms and control panel box are the key to the success of the project. The design is simple, safe and high-speed operation, efficient use of space.
- Further, the machine can be used as a study equipment for understanding pick and place operation.
- Future work could be taken up by developing fully automatic the system.

ACKNOWLEDGEMENT

The authors would like to acknowledge the support of the management of National University of Science and Technology for the completion of the current research paper and also wish to thank Mr. Ahmed Ishaq Ali Al-Bloushi, former student of the CoE for his contribution towards the initial development of the machine.

REFERENCES

[1] Rajgure S.D, Aakash D Chougale, Ajit N Bhatkande, Suraj A Bhamare, Swaroop S Chougale, *"A Review on Design and Development of Pick and Place Robotic Arm"*, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) 2018 pp. 74.

[2] Harish K, Megha D, Shuklambari M, Amit K, Chaitanya K Jambotkar, *"Pick and Place Robotic Arm Using Arduino"* International Journal of Science, Engineering and Technology Research (IJSETR) Volume 6, Issue 12, December 2017, pp. 1568-73.

[3] Kaustubh Ghadge, Saurabh More, Pravin Gaikwad, Shrenik Chillal *"Robotic Arm for Pick and Place Application"* International Journal of Mechanical Engineering and Technology (IJMET) Volume 9, Issue 1, January 2018, pp. 125–133.

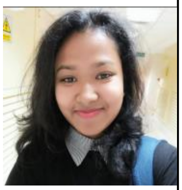
[4] Vishakha Borkar and G.K.Andurkar *"Development of Pick and Place Robot for Industrial applications"*, IRJET, Vol.4, Issue 9, September 2017, pp. 347-356

[5] Bicci A and Kumar V, *"Robotic grasping and contact: A review"*, Proc. IEEE Int. Conf. Robot. Automation, April 2000, pp. 348–353.

[6] Kragten G A and John R. Amend, "*Under actuated hands: fundamentals, performance analysis and design*" IEEE Transaction on Robotics, 2011, Vol. 28.

[7] Eizicovits D and Berman S, *"Efficient sensory-grounded grasp pose quality mapping for gripper".* Robotics and Automation Systems, Vol.62, 2014, pp. 1208–1219.

BIOGRAPHIES



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His academic career is supplemented with several reputed awards and funded projects. His research interests include Thermal Engineering, Refrigeration systems, and Solar Energy applications.